OIPE IAP44 SEP 25 2006 PATENT & TRADEMARK OFFICE

ROTATABLE DUCT TYPE SHROUDED ROTATING WING

BACKGROUND OF THE INVENTION

~~[Name of Document] Specification~~

~~[Title of the Invention]~~

~~Rotatable Duct Type Shrouded Rotating Wing~~

~~[~~Field of Art~~]~~

[0001]

The present invention relates to a shrouded rotating wing having an opening of a size ~~(hereinafter referred to as "caliber") exceeding~~ a radius of approximately 3 m and operating based on the principle of a linear motor driving ~~principle. Even when attached to a rotatable object such as, for example, a turntable and subjected to a rapid change of blow-off direction, the shrouded rotating wing can ensure a stable drive.~~

~~[~~Background Art~~]~~

[0002]

The mechanism of coupling ~~an~~ output from a prime mover, such as a turbine positioned near the center of a rotating wing, to a central driving shaft for rotation of the~~of the rotating wing to rotate~~ blades, thereby obtaining lift or thrust, has heretofore been used frequently in helicopters and other rotorcrafts. However, the method of making a rotating wing rotate around~~through~~ a shaft

defining the central axis~~located centrally~~ of ~~the~~ rotation requires a vast amount of energy and thus the efficiency has been low.

[0003]

Japanese "Kokai" (laid-open application publications) 2001-097288 and H07-205897 disclose~~Patent Literatures 3 and 4 propose to apply~~ a shrouded rotating wing for use as~~to~~ a tail rotor ~~portion~~ of a single rotor type helicopter. This shrouded rotating wing can rotate blades efficiently and change the rotational speed freely by making a change from the conventional method of transferring power to the central shaft of rotation to a method of generating a driving force at the wing tips.

[0004]

Kokai H07-205897~~Patent Literature 4~~ discloses a driving method based on a linear motor principle using shroud-side magnets and wing-tip magnets as means for generating a driving force at wing tips. As disclosed therein,~~forms for carrying out the driving method, it proposes a method of fitting~~ the wing-tip magnets may be fitted into the shroud or~~side and a method wherein the wing-tip magnets are~~ allowed to float within a space near the shroud-side magnets. In one embodiment wherein the wing tip magnets are fitted into the shroud,~~connection with~~

~~the former method, it further proposes a method using~~ neither a rotary shaft nor a hub for connecting~~in~~ the wing center portions of rotor blades is used and, in another such embodiment, ~~a method wherein~~ the ~~wing center portions of~~ rotor blades are connected to a rotary shaft. However, if~~in the former type wherein~~ the wing tip magnets~~tips~~ are fitted into ~~a~~the shroud and neither a rotary shaft nor a hub is used, when the shrouded rotating wing is of a large caliber and is used in a horizontal position, blades tend to fall off due to their own weight and the rotating wing cannot withstand a sudden change of direction. In the type using a rotary shaft to which the~~in the wing center portions of~~ rotor blades are connected, no consideration is given to expansion and contraction of the rotor blades, so when the wing caliber is large, the wing tips fitted in the shroud are pulled strongly toward the ~~wing~~ center ~~portions~~ due to the ~~own~~ weight of the rotor blades, e.g. at the time of parking, resulting in an increase in~~the~~ resistance ~~increases~~ to ~~an unrotatable extent~~rotation. Even if the rotating wing can start to~~and~~ begin rotating, there is a great possibility that~~of~~ the rotating wing will become~~becoming~~ unrotatable because no consideration is given to expansion and contraction due to~~induced by a~~ centrifugal force or heat. In the ~~latter~~ type wherein the

wing tips are allowed to float near the intra-shroud magnets, due to deflection or distortion of the rotor blades during parking, the wing-tip magnets tend to fall ~~off from the space in~~and the ~~shroud and the~~ gap between the intra-shroud magnets and the wing-tip magnets increases~~largely~~, making the generation of a driving force impossible. Thus,
a shrouded rotating wing having a small radius~~caliber~~ of about 50 to 60 cm ~~in terms of radius~~ is practical~~applicable~~ when used in the vertical position, that is, when used as~~in~~ a tail rotor ~~portion~~ of a single rotor type, but it is very difficult to use a shrouded rotating wing of a large caliber in a~~the~~ horizontal orientation~~position~~ or ~~in a place~~ where the blow-off direction is changed rapidly such as that in Japanese Patent Application 2003-290873~~Literature 1~~.

[0005]

In Japanese Kokai 2001-097288~~Patent Literature 3~~, the principle of an electric motor (basically the same as the principle of a linear motor) is enlarged by mounting~~.~~ ~~According to this enlarged principle,~~ a rectifier ~~is mounted~~ on a rotary shaft whereby~~and~~ an electric current converted to an alternating voltage by the rectifier is conducted from the wing tips onto a ring, through the rotor

blades, to ~~magnetize~~energize electromagnetic coils including an iron core which are embedded in the ring, thereby affording a driving force. Therefore, the ring and the blade tips are fixed together, and when the blades expand or contract to a larger extent than the estimated 3~5 mm ~~estimated by the inventor concerned~~, the operation of the rotating wing becomes difficult. Besides, since the coils through which~~for flowing therein of~~ an electric current flows to generate a magnetic force are embedded together with an iron core into the ring, it is presumed that the ring itself will produce heat. When these influences are taken into account, even if the rotating wing is used in ~~such~~ a vertical position as illustrated in the drawings of Kokai 2001-097288~~Patent Literature 3~~, the diameter of 1 to 1.2 m (radius 50~60 cm) estimated by the inventor ~~concerned~~ is considered to be the~~a~~ limit for~~of~~ size capable of ~~to~~ being manufactured.

[0006]

As reported in Japanese Patent Application 2002-383031 and Kokai 2001-097288~~Patent Literatures 2 and 3 have noticed~~, the length of each rotor blade changes due to ~~a~~ centrifugal force ~~thereof~~ or a change in temperature. When the rotating wing ~~concerned~~ is about 0.5 to 0.6 m (50 to 60 cm) in radius and is used in a vertical position, as a ~~like~~

~~the~~ tail rotor (Kokai 2001-097288 and H07-205897)~~as in Patent Literatures 3 and 4~~, a change in length, even when estimated to be~~a~~ maximum~~ value~~, is about 0.6% of the rotor blade length, i.e., 0.003 to 0.004 m (3 to 4 mm). Thus, the change is within the single digit range of millimeters ~~unit~~ and therefore can be absorbed by an outer projection or the like of the ring as in Kokai 2001-097288~~Patent Literature 3~~. However, when the rotating wing is used horizontally as~~in the position of~~ a main rotor, the influence of deflection or distortion of the rotor blades is added ~~in addition~~ to that of the centrifugal force and the temperature change, and during parking, a decrease in projection radius of about 2% is observed in the direction opposite to the direction of the centrifugal force~~direction~~. When the radius of the main motor is 5m, the~~distance of~~ expansion caused by ~~the~~ centrifugal force, for example, is about 0.03 m (3 cm) and the~~a~~ decrease in projection radius due to deflection or distortion is as large as about 0.1 m (10 cm), with the total being 0.13 m (13 cm) which is on~~of~~ the order of ten-odd centimeters. Thus, in the methods disclosed in Kokai 2001-097288 and H07-205897~~Patent Literatures 3 and 4~~, it is extremely difficult to maintain an appropriate gap between the magnets which create the~~a~~ driving force and it has so far

been impossible to adopt ~~such an operation~~the method disclosed~~as~~ in ~~Patent Literature 1~~Japanese Patent Application 2003-290873.

[0007]

In Japanese application 2002-383031~~Patent Literature 2~~, in order to absorb deflection and distortion of the rotor blades which can cause a~~exert influence on the~~ change in radius of gyration reaching ten-odd centimeters, and to thereby keep~~keeping~~ the gap between the shroud-side magnets and the rotor blade wing-tip magnets at an appropriate value, ~~and~~ allowing the linear motor driving principle to be exhibited in a stable manner, an electromechanical device is installed within each rotor blade. However, the weight of the rotor blades is increased~~increases~~ and the structure is~~thereof becomes~~ complicated, resulting in an increase in the number of parts and ~~a~~ fear of an increase in the number of failure generating factors. Moreover, the wing~~d~~ tips are each independent, so when a load is imposed on a certain specific rotor blade, the dispersion of the load is insufficient and the load of its~~the~~ wing tip ~~of that portion~~ imposed on the shroud becomes large. Particularly, when the rotating wing is put on a single-shaft turntable and attached to a flying body as in Japanese Patent Application 2003-290873~~Literature 1~~,

abnormal ~~pressures~~forces are generated against the shroud at two positions, one of which is the nearest to and the other remotest from a side wall of the flying body, by a gyro effect. Even if such portions are strengthened, the service life may be extremely shortened ~~extremely~~ or ~~as the case may be~~ the portions in question may be damaged.

[0008]

~~[Patent Literature 1]~~

~~Japanese Patent Application No. 2003-290873 (Claim 1, Fig. 13)~~

~~[Patent Literature 2]~~

~~Japanese Patent Application No. 2002-383031 (Claim 1, Figs. 1, 2 and 3)~~

~~[Patent Literature 3]~~

~~Japanese Patent Laid-Open Publication No. 2001-097288 (Claims 1, 2 and 6, Paragraphs 0024, 0049 and 0050, Figs. 7 and 8)~~

~~[Patent Literature 4]~~

~~Japanese Patent Laid-Open Publication No. Hei 7-(1995)-205897 (Claim 1, Paragraph 0008, Figs. 1, 2 and 3)~~

~~[Disclosure of the Invention]~~

~~[Problems to be Solved by the Invention]~~

~~[0009]~~

A shrouded rotating wing based on the driving principle of a linear motor or a shrouded rotating wing based on the principle of an electric motor is simple in structure and light in weight when it is of a small caliber and is used vertically. However, when a shrouded rotating wing of a large caliber is used horizontally, it may become difficult keep an appropriate ~~the~~ gap between the driving force generating electromagnets and permanent magnets, due to deflection or distortion induced by ~~a~~ centrifugal force, heat, or due to the ~~own~~ weight of its rotor blades, or the rotation of the rotatable portion may become difficult due to compression caused by expansion or contraction of its rotor blades, for example. Further, if an attempt is made to keep the gap between electromagnets and permanent magnets appropriate with use of an electromechanical device, not only does the structure become~~s~~ complicated, but also the weight of rotor blades, etc. is increased~~increases~~. Although~~Even if~~ there is~~occurs~~ no problem when a shrouded rotating wing is used without a sudden change in direction, in the case~~despite it being~~ of a large caliber ~~and~~ used in a horizontal direction, a strong force~~pressure~~ based on a gyro effect is developed against the shroud if the direction is changed suddenly.

SUMMARY OF THE INVENTION

~~[Means for Solving the Problems]~~

~~[0010]~~[0009]

Accordingly,~~According to~~ the present invention provides a shrouded rotating wing including~~, first there is provided~~ a duct (hereinafter referred to as "rotatable duct"~~, i.e., vertical direction~~) having permanent magnets and capable of stable rotation by~~rotating stably in accordance with~~ a rotating magnetic field created by electromagnets disposed within a shroud. The shroud and the rotatable duct are in constant vertical contact with each other.~~ constantly in the vertical direction (the direction orthogonal to a rotating surface) and are in a shape such that the~~ The inner periphery ~~portion~~ of the shroud faces~~located outside is covered with~~ the outer periphery ~~portion~~ of the rotatable duct located inside the shroud with~~. In the horizontal direction (the direction parallel to the rotating surface, i.e., lateral direction) the shroud and the rotatable duct are disposed through~~ an appropriate gap therebetween to allow for~~ space so as not to be influenced by~~ expansion and contraction of the rotatable duct itself or of rotor blades connected to the inner periphery ~~portion~~ of the rotatable duct~~, and are normally not in contact with each other~~. Electromagnets are arranged around~~in~~ the inner periphery ~~portion~~ of the

shroud, while permanent magnets are arranged around~~in~~ the outer periphery ~~portion~~ of the rotatable duct corresponding~~shroud correspondingly~~ to the electromagnets. Therefore, when a rotating magnetic field is developed in the shroud, the rotatable duct rotates in response thereto.

[0010]~~[0011]~~

In the case where the rotor blades whose wing tips (distal ends)are connected to the inner periphery~~portion~~ of the rotatable duct are of a small caliber, i.e. a radius of about 3 m~~in terms of radius~~, the inner ends~~wing center portions~~ thereof are connected directly to a hub or a central shaft defining an~~(hereinafter referred to as "hub or the like" hereinafter) located at the~~ axis of rotation. In the case of a large caliber exceeding a radius of about 5 m~~in radius~~, a support portion that is rotatable (hereinafter referred to as "rotatable support ring~~portion~~"), for vertically supporting the rotor blades, is provided ~~in a ratio of~~ one said rotatable support portion at ~~every~~ about ~~2.5 m~~ halfway on the length of the rotor blades to prevent the rotor blades from being deflected or distorted by their own weight~~, and the wing center portions of the rotor blades are connected to the hub or the like located in the axis of rotation~~.

[0011] ~~[0012]~~

Thus, ~~in~~ the shrouded rotating wing of the present invention has~~using~~, as main components, a shroud, rotatable duct, rotatable support ring(s)~~portion~~, hub or shaft~~the like~~, and rotor blades. Even~~, even~~ when the shrouded rotating wing ~~used~~ is of a large caliber, deflection and distortion of the rotor blades can be prevented by the rotatable support ring(s)~~portion~~, ~~whereby, as to expansion and contraction of the rotatable duct to which~~ a countermeasure ~~is to be taken, a limitation can be made~~ to the influence of both centrifugal force and heat. ~~Therefore, even in the case of a rotating wing of a large caliber, the countermeasure to such expansion and contraction can be attained by only ensuring an appropriate space in the horizontal direction (the direction parallel to the rotating surface, i.e., lateral direction) between the shroud and the rotatable duct which covers the inner periphery portion of the shroud.~~

[0012] ~~[0013]~~

Further, since the tip (distal end)~~wing tips~~ of each blade is connected to the rotatable duct, even if the rotor blades are attached to a turntable which changes~~capable of changing~~ the direction rapidly ~~and is operated~~, the force generated by a~~pressure based on~~ gyro effect and imposed on

the wing tips is dispersed by the rotary duct and ~~such a partial and~~ strong force~~pressure~~ that might otherwise cause damage~~s~~ to the shroud is avoided~~not developed~~. Accordingly, it is possible to ensure constant and~~a~~ stable rotation ~~constantly~~ and hence the resulting lift and thrust can be obtained in a stable manner.

~~[Effect of the Invention]~~

[0013]~~[0014]~~

In comparison with the conventional devices~~method~~ which can afford only a small lift despite high~~a large~~ horsepower, the present invention permits the generation of a large lift with even less~~with a small~~ power. Therefore, if instead~~the method~~ of ~~connecting~~ a drive unit connected to ~~the central axis of~~ a rotating shaft~~wing~~ to rotate blades and obtain lift ~~such~~ as in a conventional helicopter, ~~or the like is not adopted and instead~~ the rotatable duct type shrouded rotating wing based on the linear motor driving principle according to the present invention is used as~~applied to the position of~~ a main rotor, it is possible to attain a~~the~~ reduction in~~of~~ weight, simplification of structure, and saving of fuel consumption. Further, while~~As to the~~ conventional shrouded rotating wings are~~wing so far invented, it is~~ difficult to use ~~it~~ horizontally if they have~~in a state of~~ a large

radius~~caliber. On the other hand~~, according to the present invention, not only can rotor blades of a large radius~~caliber can~~ be used in a horizontal position, but also when~~even if~~ such rotor blades are used as~~mounted to~~ a turntable which changes~~capable of changing~~ the blow-off direction rapidly~~and are operated~~, it is possible to obtain a stable driving force. Thus, the shrouded rotating wing of the present invention is usable in the manner disclosed in Japanese~~applicable also to~~ Patent Application 2003-290873~~Literature 1~~.

[0014]~~[0015]~~

In a conventional rotorcraft such as a helicopter, the transfer of generated lift to the body of the rotorcraft is performed through the central~~wing center~~ portions of the rotor blades, and wing tips (blade distal ends) are free~~open to the air~~. Therefore, at the wing tips where the air speed is the highest of the~~among~~ mass points on the~~of~~ rotor blades, it is necessary to prevent the wing tips from being bent~~stripped~~ upward due to a relative excess of lift. More particularly, it is necessary to use a complicated structure including a twist which is effected for example by varying~~making~~ the ~~different~~ angle of elevation of the rotor blades between wing tips and wing center. On the other hand, in the present invention, since

the transfer of generated lift is performed at the~~through~~ wing tips, there is no fear of the wing tips being bent~~stripped~~ upward. Therefore, ~~it is not necessary to perform a~~ twisting of~~work or the like for~~ the rotor blades is not necessary and~~, that is,~~ the manufacturing cost can be reduced.

~~[Best Mode for Carrying Out the Invention]~~

[0015]

Thus, the present invention provides a lift device and a thrust device both capable of producing a light-weight and strong air flow volume in a stable manner when applied to a helicopter, a flying platform, or such a flying body as in Japanese Patent Application 2003-290873.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

Fig. 1 is a schematic planar view~~schematically shows the appearance~~ of a first embodiment of a rotatable duct type shrouded rotating wing based on the linear motor driving principle according to the present invention.

Fig. 2 is a front view of the rotatable duct type shrouded rotating wing (a side view thereof is also the same) of the first embodiment.

Fig. 3 is a horizontal sectional view of the rotatable duct type shrouded rotating wing of the first

embodiment.

Fig. 4 is a horizontal sectional view of only the rotatable elements, i.e. the rotatable duct and rotor blades, in the rotary duct type shrouded rotating wing of the first embodiment.

Fig. 5 is a vertical sectional view of the rotatable duct type shrouded rotating wing of the first embodiment.

Fig. 6 is a vertical sectional view of only the rotatable elements, i.e. the rotatable duct and the rotor blades, in the rotary duct type shrouded rotating wing of the first embodiment.

Fig. 7 is a vertical sectional view of only fixed elements such as the shroud and fixed support portion in the rotatable duct type shrouded rotating wing of the first embodiment.

Fig. 8 is a vertical sectional view of the shroud, rotatable duct, and the vicinity thereof.

Fig. 9 is a plan view of the rotatable duct type shrouded rotating wing as mounted to a turntable in a second embodiment.

Fig. 10 is a front view of the rotatable duct type shrouded rotating wing as mounted to the turntable.

Fig. 11 is a side view of the rotatable duct type shrouded rotating wing as mounted to the turntable.

~~[First Embodiment]~~

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017]

Figs. 1 to 8 illustrate a rotatable duct type shrouded rotating wing according to an embodiment of the present invention wherein electromagnets 3 are arranged around~~annularly in~~ the inner periphery ~~portion~~ of a shroud 2, while permanent magnets 4 are arranged on~~in~~ the outer periphery ~~portion~~ of a rotatable duct 5, and a rotating magnetic field is generated by the shroud-side electromagnets 3 to rotate the rotatable duct 5 and rotor blades 6, with consequent generation of lift and thrust.

~~[Second Embodiment]~~

~~[0018]~~

~~Figs. 9 to 11 illustrate an embodiment of the present invention in which the rotatable duct type shrouded rotating wing is mounted to a turntable (a rapid wind direction changer) which is used in Patent Literature 1.~~

~~[Industrial Applicability]~~

~~[0019]~~

~~It is possible to provide a lift device and a thrust device both capable of producing a light-weight and strong air volume in a stable manner when applied to a helicopter, a flying platform, or such a flying body as in Patent~~

~~Literature 1.~~

~~[Brief Description of the Drawings]~~

~~[0020]~~

~~Fig. 1 is a plan view of a rotatable duct type shrouded rotating wing based on the linear motor driving principle according to the present invention.~~

~~Fig. 2 is a front view of the rotatable duct type shrouded rotating wing (a side view thereof is also the same).~~

~~Fig. 3 is a horizontal sectional view of the rotatable duct type shrouded rotating wing.~~

~~Fig. 4 is a horizontal sectional view of only rotatable portions such as a rotatable duct and rotor blades in the rotary duct type shrouded rotating wing.~~ In the rotating wing, the air speed at mass points thereof increases with distance~~separation~~ from the rotational center. Therefore, when the angles of elevation of the rotor blades are the same at any position, the lift at wing tips becomes excessive in comparison with that at the inner wing (blade) ends~~center portions~~, resulting in ~~such a shape as~~ the wing tips being bent~~stripped~~ upward with rotation of the rotor blades, and the lift against the ~~just~~ underlying position decreasing~~decreases~~. To avoid this problem~~inconvenience~~, open wing-tip rotor blades used in

the recent rotorcrafts are designed such that the angle of elevation of each rotor blade is made deep near its inner end~~the wing center portion the rotor blade~~ and ~~is~~ made shallow near its outer end ("distal end" or~~the~~ "wing tip") to prevent the wing tip from being bent~~stripped~~ upward, thereby permitting a uniform lift to be obtained throughout the whole of the rotor blades. Such a design is unavoidable in the conventional rotorcrafts such as helicopters because the lift generated in the rotor blades is used as the lift of the rotorcraft body via a rotary shaft located at the wing center. However, an optimized ~~place of the~~ balance between the air resistance of rotation and the generated lift is present at only a part on the rotor blades, and in the other portions the angle of elevation ~~of each rotor blade~~ has not so far been considered optimal. On the other hand, in the present invention, lift is transferred to a rotorcraft body via the wing tips, so there is no problem even if the generated lift is offset to wing tips. Thus, an optimized value of elevation angle can be provided at all~~imparted to any portion~~ portions of the rotor blades. For this reason, the rotor blades according to the present invention are flat and free of any twist.

~~Fig. 5 is a vertical sectional view of the rotatable~~

~~duct type shrouded rotating wing.~~

~~Fig. 6 is a vertical sectional view of only rotatable portions such as the rotatable duct and the rotor blades in the rotary duct type shrouded rotating wing.~~

~~Fig. 7 is a vertical sectional view of only unrotatable portions such as the shroud and fixed support portion in the rotatable duct type shrouded rotating wing.~~

~~Fig. 8 is a vertical sectional view of the shroud, rotatable duct, and the vicinity thereof, which generate a driving force of the rotatable duct type shrouded rotating wing.~~

As best seen in Fig. 8, the~~The~~ rotatable duct 5 is formed~~constituted by~~ a cylinder and upper and lower portions of the cylinder are constantly in contact with the shroud 2~~constantly~~ through upper and lower bearings 10~~so as to enclose the shroud from the inside~~. Lift or thrust of the rotor blades 6 is transmitted to the shroud 2 side through the bearings 10~~contact portions~~. ~~Conversely~~However, the outer periphery ~~portion~~ of the rotatable duct 5 and the inner periphery ~~portion~~ of the shroud 2 are normally~~usually~~ spaced a predetermined distance from each other and not in contact~~ with each other~~. This distance is an appropriate distance such that when the rotating portion of the rotatable duct, for example, expands to its maximum~~the~~

~~greatest~~ extent due to ~~a~~ centrifugal force or heat, it comes into contact with a bearing 9 and/or 11 provided on the shroud side and is thereby stabilized~~becomes stable~~.

As shown in Figs. 1, 2 and 7 fixed support bars 1, in a number corresponding to the number of blades 6, are connected to an upper portion of the shroud 2 and extend upward and inwardly to connection with an upper shaft 13. Likewise, a plurality of fixed support bars 1, in a number corresponding to the number of blades 6, are connected to a lower surface of the shroud 2 and extend downward and inwardly to connection with a lower shaft 14.

As shown in Figs. 1, 3, 4, 5 and 6, a rotatable support ring(s) 7 is fixed to and extends vertically above and below blades 6. The upper and lower ends of the rotatable support ring 7 respectively ride on upper and lower support elements 15 and 16.

As best seen in Fig. 8, the rotatable duct 5 has upper and lower flange elements 17, 18 which extend radially outward from its outer peripheral surface 24. These flange elements 17, 18 are in contact with fixed, annular horizontal surfaces 20, 19, respectively provided on arms 22 and 23 of the shroud 2. A magnet support 21, in which permanent magnets 4 are mounted extends between flange elements 17, 18, radially outward from the outer

peripheral surface 24 of the rotatable duct 5, and into the space between arms 22, 23 of the shroud 2.

Figs. 9 to 11 illustrate a second embodiment of the present invention in which the rotatable duct type shrouded rotating wing is mounted as a turntable (a rapid wind direction changer) which is used as disclosed in Japanese Patent Application 2003-290873.

~~Fig. 9 is a plan view of the rotatable duct type shrouded rotating wing as mounted to a turntable.~~

~~Fig. 10 is a front view of the rotatable duct type shrouded rotating wing as mounted to the turntable.~~

~~Fig. 11 is a side view of the rotatable duct type shrouded rotating wing as mounted to the turntable.~~

~~[Explanation of Reference Numerals]~~

~~[0021]~~

~~1 (fixed) support portion~~

~~2 shroud~~

~~3 electromagnet~~

~~4 permanent magnet~~

~~5 rotatable duct~~

~~6 rotor blade~~

~~7 rotatable support portion~~

~~8 hub~~

~~9 bearing (contact only upon expansion)~~

~~10 bearing (contact constantly)~~

~~11 bearing (contact only upon expansion)~~

~~12 turntable~~

~~[Name of Document] Claims~~

~~1. A rotatable duct type shrouded rotating wing having a shrouded rotating wing and its an opening size (hereinafter referred to as "caliber") exceeding a radius of approximately 3 m and based on a linear motor driving principle, said rotary type shrouded rotating wing comprising the following shroud, rotary duct, rotatable support portions, hub or the like, and rotor blades, as main components:~~

~~(1) a shroud with electromagnets able to form a rotating magnetic field being arranged annularly in the interior thereof;~~

~~(2) a duct that is rotatable (hereinafter referred to as "rotatable duct") with permanent magnets and rotor blades connected to outer and inner periphery portions thereof respectively, said rotatable duct having a shape such that in the vertical direction (the direction orthogonal to a rotating surface, i.e., vertical direction) the rotatable duct is in contact with said shroud constantly, while in the horizontal direction (the direction parallel to the rotating surface, i.e., lateral direction), the rotatable duct encloses the inner periphery portion of said shroud while normally maintaining an appropriate contactless space to permit expansion and contraction of the rotatable duct;~~

~~(3) a support portion that is rotatable (hereinafter referred to as "rotatable support portion") formed in the shape of a cylinder sandwiching said rotor blades in the vertical direction (the direction orthogonal to the rotating surface, i.e., vertical direction), said rotatable support portion being connected at a central portion in the vertical direction (the direction orthogonal to the rotating surface, i.e., vertical direction) of the cylinder to said rotor blades and being in contact at both ends in the vertical direction (the direction orthogonal to the rotating surface, i.e., vertical direction) of the cylinder with a fixed support portion, thereby holding the rotor blades in the vertical direction (the direction orthogonal to the rotating surface, i.e., vertical direction) to prevent the rotor blades from being deflected or distorted by their own weight and permitting limitation to the influence of both centrifugal force and heat with respect to expansion and contraction of said rotatable duct which should be coped with, said rotatable support portion being rotatable together with said rotor blades while both ends in the vertical direction (the direction orthogonal to the rotating surface, i.e., vertical direction) of the cylinder are kept in contact with the fixed support portion;~~

~~(4) a hub or a central shaft (hereinafter referred toas~~

~~"hub or the like") positioned at the center of rotation of said rotor blades by the fixed support portion to connect wing center portions of the rotor blades; and~~

~~(5) said rotor blades, the rotor blades having wing tips connected to the inner periphery portion of said rotatable duct and wing center portions connected to the hub or the like, the rotor blades having said rotatable support portion in a ratio of one said rotatable support portion at every about 2.5 m halfway on blades thereof from the direction of said wing center portions to said wing chip,~~

~~wherein, even in an environment involving a rapid change of a blow-off direction of the shrouded rotating wing, lift and thrust which the rotor blades connected to the rotatable duct generates can be obtained always stably irrespective of the caliber or a mounted state of the shrouded rotating wing to a flying body, or the blow-off direction.~~

~~[Name of Document] Abstract~~ ABSTRACT OF THE DISCLOSURE

~~[Summary]~~

~~[Subject]~~

~~In the conventional shrouded rotating wing, if it is of a large caliber and used in a horizontal position, it is difficult for rotatable portions to rotate due to deflection or distortion of rotor blades or due to compression resulting from expansion caused by a centrifugal force and heat, although there occurs no problem in case of the shrouded rotating wing being of a small caliber and used in a vertical position. Moreover, if an attempt is made to remedy expansion and contraction, such as deflection or distortion with use of an electromechanical device, the structure becomes complicated and the weight increases.~~

~~[Solution]~~

In a~~the~~ rotatable duct type shrouded rotating wing ~~according to the present invention~~, permanent magnets are arranged in the outer periphery ~~portion~~ of a rotatable duct, rotor blades are connected to the inner periphery ~~portion~~ of the rotatable duct, the rotor blades having a rotatable support portion at about every ~~about~~ 2.5 m to prevent deflection or distortion.~~, the~~ The shroud and the rotatable duct are constantly in vertical contact with each

other ~~in the vertical direction~~, and an appropriate horizontal spacing~~space~~ is provided~~ensured~~ between the inner periphery ~~portion~~ of the shroud and the outer periphery ~~portion~~ of the rotatable duct to permit expansion and contraction of the rotatable duct and the rotor blades. Accordingly~~According to this construction~~, even if the shrouded rotating wing is of a large radius, ~~caliber and~~ is used in a horizontal orientation~~position~~ and undergoes a rapid change of direction ~~in a~~ mounted ~~state thereof~~ to a turntable, it ~~can rotate~~ always rotates stably to~~and can~~ generate lift and thrust.

~~[Selected Drawing]~~

~~Fig.1~~